MODELING AND STATIC MODAL ANALYSIS OF RACING GOKART CHASSIS USING VARIOUS MATERIALS WITH FEM

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ABSTRACT

Chassis is basis foundation of any Automobile locomotive. Go-Kart is primary form of racing car where engineers can make use of theoretical knowledge with practical existence. A Go-Kart is a small four wheeled vehicles without suspension or differential. It is a light powered vehicle which is generally used for racing. There are various kinds of chassis out of which Tubular frame chassis are suitable for small vehicle. Design of chassis is on the basis of rigidity, strength and safety of driver by considering car that is durable as well as reliable whose material easily available in India. The kart has been designed using sound design principles .Go-kart is small four wheeler vehicle without suspension light powered vehicle used for racing. Basically CATIA software are used for designing of Chassis whereas ANSYS- BENCHWORK software is used for Analysis of Chassis. Chassis is made up of joining various small links by using welding with limited number of joints so to avoid increase of weight and make the chassis strong enough to withstand high load.

The aim of the project is A fully parametric model designed in catia v5 of the gokart chassis software. Model obtained in igs is analyzed using ANSYS 15 (work bench) to obtain stresses, strain, deformation, Shear stress and in modal analysis, find out the deformations different frequencies, Front and side impact manual calculations .Finally, we compare the results obtained from ANSYS **(SATIC, MODAL)** and compared different materials. (**AISI 1030, AISI 4340, ASTM A710**) finally concluded the which material is the best based on the results.

1 INTRODUCTION TO GO KARTS

Kart racing or karting is a variant of open-wheel motorsport with small, open, four-wheeled vehicles called karts, go-karts, or shifter karts depending on the design. They are usually raced on scaled-down circuits. Karting is commonly perceived as the stepping stone to the higher ranks of motorsports.
The Go-Kart is a small powered single/double occupancy racing vehicle, having a similar functioning as of a F1 vehicle but specifically meant for low powered engines. The Go-kart tracks are smaller when compared to F1 tracks but the door to F1 opens after being part of International Go-Kart Championships.

The first go-kart was made in 1956 by the man named Art Ingels also called the father of go-karts. It was made from scrap metal and a lawn mower engine.

Go-karting is a big craze to Americans and Europeans. It is initially created in United states in 1950's and used for recreational purpose. Gradually it became a good hobby and other countries followed it. In India go karting is getting ready to make waves. A racing track is ready in Nagpur for Go karting and chennai is also trying to make one.

Indian companies like MRF, Indus motors are also producing Go karts. Go karts help to unleash the budding talents of engineers and emerging drivers for formula one.
Our primary objective is to design a safe and functional vehicle based on a rigid and torsion-free frame, well mounted power train and to understand the finer aspects of vehicle design with the ulterior motive of fabricating prototype vehicle that could be manufactured for consumer sale, while strictly adhering to the competition rule. The secondary objective is to enhance driver's comfort and safety, and to increase the performance of the vehicle.

Figure 1 go kart vehicle

We approached our design by considering all possible alternatives for a system & modelling them in CAD software like CATIA, Solid works etc. and subjected to analysis using ANSYS FEA software. Based on analyses result, the model was modified and retested and a final design was frozen. The design process of the vehicle is iterative and is based on various engineering and reverse enginee ring processes depending upon the availability, cost and other such factors.

So the design process focuses on following objectives: Safety, Serviceability, Strength, ruggedness, Standardization, Cost, Driving feel and ergonomics, Aesthetics.

The automotive chassis is tasked with holding all the components together while driving, and transferring vertical and lateral loads, caused by accelerations, on the chassis through the wheels. Most engineering students will have an understanding of forces and torques long before they read this. Some people stress full with material choice but once you are familiar with this it is the key to a good space frame. While this will make the design better it can still benefit from this more general design principles. The design section of the book will talk more about these items . We designed a CAD model of the chassis on the 3D modelling software. Using this design software allowed the team to visualize the design in 3-D space and reduce errors in fabrication. The main criterion in chassis design was to achieve perfect balance between a spacious and ergonomic driver area with easy ingress and egress, and compact dimensions to achieve the required weight and torsional rigidity criteria. Following this criterion, the required dimensions were roughly set using a virtual template to achieve the necessary clearances in case of a rollover situation. After a series of design changes and subsequent calculations, the final chassis design was decided upon. The design process of the vehicle is iterative and is based on various engineering and reverse engineering processes depending upon the availability, cost and other such factors. So the design process focuses on following objectives:

Safety

- Serviceability
- Strength
- Ruggedness
- Standardization
- Cost
- Driving Feel And Ergonomic
- Aesthetics
- Durability
- Light Weight
- High Performance

1.2 ROLE OF CHASSIS IN AUTOMOTIVES

Every vehicle body consists of two parts; chassis and bodywork or superstructure. The chassis is the framework of any vehicle. Its principal function is to safely carry the maximum load for all designed operating conditions. It must also absorb engine and driveline torque, endure shock loading and accommodate twisting on uneven road surfaces. The chassis receives the reaction forces of the wheels during acceleration and braking and also absorbs aerodynamic wind forces and road shocks through the suspension. So the chassis should be engineered and built to maximize payload capability and to provide versatility, durability as well as adequate performance. To achieve a satisfactory performance, the construction of a heavy vehicle chassis is the result of careful design and rigorous testing.

2 LITERATURE REVIEW

The aim of this chapter is to provide, through some selective reference of the literature cited, a clear understanding of different ways in which a go-kart chassis was designed and other analytical investigations on the frame that were done previously. These technical publications and journals published in national and international levels helped us in enhancing the progress of our work.

2.1 PREVIOUS RESEARCH PAPERS CITED

Simranjeet Singh et al. [1] stated that their main objective of the design was to make a car that is durable as well as reliable and will last through the endurance using parts that are cost effective and easily available in India. The kart has been designed using sound design principles. The principle of triangulation has been extensively used

to make sure that the chassis is extremely rigid and provides a safe cocoon for the driver in case of an accident. The vehicle has been designed in such a way that the reliability is not compromised in the pursuit of speed. The wheel and suspension geometry have been designed taking into account the track layout and prevailing conditions.

Shaik Himam Saheb et al. [2] stated that their paper concentrated on explaining the design and engineering aspects of making a Go Kart. This report explained objectives, assumptions and calculations made in designing a Go Kart. The team's primary objective was to design a safe and functional vehicle based on rigid and torsion free frame. The design was chosen such that the Kart is easy to fabricate in every possible aspect.

Dr.D.Ravikanth et al. [3] stated that in India go-karting is getting ready to make waves. A racing track is ready in Nagpur for go-karting and Chennai is also trying to make one. Indian companies are also producing go-karts in small scale. MRF and Indus motors are the major bodies in karts and they are offering karts between 2 lakh and 3 lakh. But to make go-karts popular, the price must come down. For that, many people are trying to build one under 1 lakh and we had also take up the challenge and make our under 78 K. This is a dream come true. A go-kart just under ₹100000/-. So we are sure that our project will have a high demand in the industry and also we are hoping to get orders from the racing guns.

Koustubh Hajare, et al. [4] stated that their paper was aimed at the design analysis of a go kart chassis. The main intention was to do modelling and static analysis of go-kart chassis. The maximum deflection was obtained by analysis. The go-kart chassis are different from chassis of ordinary cars on the road. The paper highlighted the material used and structural formation of chassis. The strength of material, rigidity of structure and energy absorption characteristics of chassis was discussed. The modelling and analysis were performed using 3- D software such as SOLIDWORKS & ANSYS

Mr.Virendra.S.Pattanshetti et al. [5] stated that they have made the 3D model• of Go Kart and Roll Cage in Catia-V5. Roll Cage comes under the sprung mass of the Vehicle. There were a lot of forces acting on vehicle in the running condition. These forces were responsible for causing crack initiation and deformation in the vehicle. Deformation results in Stress Generation in the Roll Cage. Hence it is important to find out these areas of maximum Stresses. In this paper an attempt is made to find out these areas by carrying out FEA of the Roll Cage. They have carried out Crash Analysis (Front and Side Impact), Torsional Analysis. All these Analysis have been carried out in Hyper Works 11.0.

Ujjal Kalita et al. [6] stated that the main motive of their vehicle was driver safety. The vehicle has been designed in such a way that it can carry up to a 95th percentile male. Along with that vehicle reliability is not compromised in the pursuit of speed. Chassis was of a tubular cross section pipe, fabricated assembly of AISI 1020 grade and a few other grades. In this kart, they have used AISI 1020 class tube with 1 inch diameter and 2 mm wall thickness. A front and side impact test was also simulated for the design to ensure the safety of the driver. Frame gussets were also added in strategic locations in order to brace weak members or members that can experience high loading. Front and rear bumpers were also added to protect the vehicle in the event of front or rear impact.

D.Raghunandan et al. [7] stated that their paper aimed to model and perform• the dynamic analysis of the go-kart chassis which is of constructed with circular beams. Modelling and analysis are performed in SOLIDWORKS and ANSYS respectively. The go-kart chassis is different from ordinary car chassis. The chassis is designed in such a way that it requires less materials and ability to withstand loads applied on it. Strength and light weight are the basic consideration for choosing the chassis material. AISI 1018 is the suitable material to be used for the go-kart chassis

Mr. Kartik Kelkar et al. [8] stated that their paper was aimed at modelling the• static analysis of go-kart chassis consisting of circular beams. Modelling and analysis are performed using 3-D modelling software i.e. CATIA & static analysis in ANSYS 14.5. The maximum deflection is obtained by analysis. The go-kart chassis are different from the chassis of ordinary cars on the road. The material used and structural formation of chassis. The loads are applied to determine the deflection of chassis.

Harish Harsurkar et al. [9] stated that Go-karts come in all shapes and forms, from motor less models to high-powered racing machines, some, like Super karts, being able to beat racing cars on long circuits. Analysis is performed on Go-Kart basically for weight reduction and testing the designed components. Front Impact, Rear impact, Side impact and torsion analysis is performed on the chassis. Other components of Go kart are also analysed for better factor of safety and weight reduction

10) Mr. Kartik Kelkar1, Mr. Siddhant Gawai2, Mr. Tushar Suryawanshi3, Mr. Shaikh Ubaid4, and Mr. Rajratna Kharat5: This paper aims to do modeling the static analysis of go-kart chassis consisting of circular beams. Modeling and analysis are performed using 3-D modeling software i.e., CATIA & static analysis in ANSYS 14.5. The maximum deflection is obtained by analysis. The go-kart chassis are different from the chassis of ordinary cars on the road. The material used and structural formation of chassis. The loads are applied to determine the deflection of chassis.

11) Mr. Virendra.S. Pattanshetti: This paper deals with the Design and Analysis of Roll Cage for the Go Kart. In a Go Kart Student Car, the roll cage is one of the main components. It forms the structure or the main frame of the vehicle on which other parts like Engine, Steering, and Transmission are mounted. We have made the 3D model of Go Kart and Roll Cage in Catia-V5. Roll Cage comes under the sprung mass of the Vehicle. There are a lot of forces acting on vehicle in the running condition. These forces are responsible for causing crack initiation and deformation in the vehicle. Deformation results in Stress Generation in the Roll Cage. Hence it is important to find out these areas of maximum Stresses. In this paper an attempt is made to find out these areas by carrying out FEA of the Roll Cage. We have carried out Crash Analysis (Front and Side Impact), Torsion Analysis. All these Analysis have been carried out in Hyper Works 11.0. The design procedure follows all the rules laid down by NKRC Rule Book for Go Kart Type Cars.

12) Sannake Aniket S., Shaikh Sameer R., Khandare Shubham A., Prof. S.A. Nehatrao: A Go-Kart is a small four wheeled vehicles without suspension or differential. It is a light powered vehicle which is generally used for racing. This paper is aimed to model and perform the dynamic analysis of the go-kart chassis which is of constructed with circular beams. Modelling and analysis are performed in CREO PARAMETRIC and ANSYS respectively. The go-kart chassis is different from ordinary car chassis. The chassis is designed in such a way that it requires less materials and ability to withstand loads applied on it. Strength and light weight are the basic consideration for choosing the chassis material. AISI 1018 is the suitable material to be used for the gokart chassis which is a medium carbon steel having high tensile strength, high machinability and offers good balance of toughness and ductility.

13) Kiral Lal, Abhishek O S: A Go-kart is a small four wheeled vehicle. Go-kart, by definition, has no suspension and no differential. They are usually raced on scaled down tracks but are sometimes driven as entertainment or as a hobby by non-professionals. 'Carting is commonly perceived as the steppingstone to the higher and more expensive ranks of motor sports. Kart racing is generally accepted as the most economic form of motor sport available. As a free-time activity, it can be performed by almost anybody and permitting licensed racing for anyone from the age of 8 onwards. Kart racing is usually used as a low-cost and relatively safe way to introduce drivers to motor racing. Many people associate it with young drivers, but adults are also very active in karting. Karting is considered as the first step in any serious racer's career. It can prepare the driver for highs-speed wheel-to-wheel racing by helping develop guide reflexes, Precision car control and decision-making skills. In addition, it brings an awareness of the various parameters that can be altered to try to improve the competitiveness of the kart that also exist in other forms of motor racing.

14) Koustubh Hajare, Yuvraj Shet, and Ankush Khot: This paper aims to the design analysis of a go kart chassis. The main intention is to do modelling and static analysis of go-kart chassis. The maximum deflection is obtained by analysis. The go-kart chassis are different from chassis of ordinary cars on the road. The paper highlights the material used and structural formation of chassis. The strength of material, rigidity of structure and energy absorption characteristics of chassis is discussed. The modelling and analysis are performed using 3-D software such as SOLIDWORKS, ANSYS and HYPERMESH. The

loads are applied to determine the deflection of chassis.

15) Harshal D. Patil, Saurabh S. Bhange, and Ashish S. Deshmukh: There are many motor sports in the world. Bikes, Cars, Formula one is examples of them. But there are also motor sports which do not need professional drivers and need no great speed. The vehicles used are also very cheap. Such a motor sport is GoKarting. Go-kart is a simple four-wheeled, small engine, single seated racing car used mainly in United States. This paper explains the designing and fabricating a sound kart having high fuel economy and maximum driver comfort and compactness without compromising on kart performance. This research also includes designing kart for the performance and serviceability. Compliance with the rulebook of NKRC 2015 is compulsory and governs a significant portion of the objectives. This report describes in detail the parameters included in the entire design and considerations made for zeroing those parameters. Validation of the design is done by conducting theoretical calculations, simulations and known facts. Analyses are conducted on all major components to optimize strength and rigidity, improve vehicle performance, and to reduce complexity and manufacturing cost. The design has been modelled in CATIA V5R21; the analysis was done in ANSYS 14.5 and simulation in ADAMS14.

16) Abhijit Padhi, Ansuman Joshi, Hitesh N: had proposed a project which aims to increase the factor of safety of the Go-Kart chassis which is designed keeping in mind the rules imposed by Go – Kart Design Challenge 2015. Theoretical calculations are carried out which have been realized through several analyses. These result, coupled with appropriate research has been used to create a new chassis that possesses improved performance and safety. During front impact analysis, the chassis should meet the required factor of safety. To enhance factor of safety the computer aided design model was altered marginally such that it meets the safety requirements. An innovative method of design optimization has been discussed, without significant increase in the overall kerb weight of the chassis.

3 DESIGN OBJECTIVES OF CHASSIS

Provide full protection of the driver, by obtaining required strength and torsional rigidity, while reducing weight through diligent tubing selection Design for manufacturability, as well as cost reduction, to ensure both material and manufacturing costs are competitive with other Go Karts. Improve driver comfort by providing more lateral space in the driver compartment Maintain ease of serviceability by ensuring that chassis members do not interfere with other subsystems Deciding the cost efficiency of such in terms of large scale manufacturing. Calculation of stresses acting on the chassis of the vehicle under different loading conditions. The product can prove to be very efficient in all the aspects such as cost, drivability, maintenance, easy usage, safety etc.

1)To get knowledge of Go-Kart Chassis Design for beginner in stepwise manner so to avoid unnecessary thing and focuses on competition.

2) Focusing area of analyzing Software to get desirable result.

3) To make use of welding alternative of hydraulic press.

4)Use of welding Principle effectively without increasing weight of chassis and make it simple.

4.1 SCOPE OF PROJECT:

1. Go- kart is gaining wide popularity as it is suitable for most of people to make their own playing car as well as working car by using their knowledge and competition with other in racing.

2. Making advance engineering Knowledge to use at chassis for making it better and light weight.

3. Using variety of material to make better chassis for various applications and mostly for racing purpose.

4. Practice Engineering knowledge with budgeting for making Cost effective chassis.

4.2 DESIGN METHODOLOGY:

Design of any component is consists of three major principles:

1. Optimization

2. Safety

3. Comfort

Step 1: Collecting information and data related to gokart chassis

Step 2: A fully parametric model of the gokart chassis is created in catia software.

Step 3: Model obtained in igs is analyzed using ANSYS 14.5 (work bench) to obtain stresses, strain, deformation and in modal analysis,

Step 4: Front and side impact manual calculations are done

Step 5: Finally, we compare the results obtained from ANSYS (SATIC, MODAL) and compared different materials

5. INTRODUCTION TO CATIA V5R20

Welcome to CATIA (Computer Aided Three Dimensional Interactive Application). As anew user of this software package, you will join hands with thousands of users of this high-end CAD/CAM/CAE tool worldwide. If you are already familiar with the previous releases, you can upgrade your designing skills with the tremendous improvement in this latest release. CATIA V5, developed by Dasssault Systems, France, is a completely re-engineered, Next-generation family of CAD/CAM/CAE software solutions for Product Lifecycle Management. Through its exceptionally easy-to-use and state-of-the-art user interface, CATIA V5 delivers innovative technologies for maximum productivity and creativity, from the inception concept to the final product. CATIA V5 reduces the learning curve, as it allows the flexibility of using featurebased and parametric designs. CATIA V5 provides three basic platforms: P1, P2, and P3. P1 is for small and medium-sized process-oriented companies that wish to grow toward the large scale digitized product definition. P2 is for the advanced design engineering companies that require product, process, and resource modeling. P3 is for the high-end design applications and is basically for Automotive and Aerospace Industry, where high quality surfacing or Class-A surfacing is used. The subject of interpretability offered by CATIA V5 includes receiving legacy data from the other CAD systems and even between its own product data management modules. The real benefit t is that the links remain associative. As a result, any change made to this external data gets notified and the model can be updated quickly.

5.1 DESIGN PROCEDUE IN CATIA

Create the rectangular profile in sketcher workbench as per the below dimensions after go to part design create plane now select plan go to sketcher now create two hollow circles at the end of the rectangle profile again go to part design apply rib option now converted into the solid body.

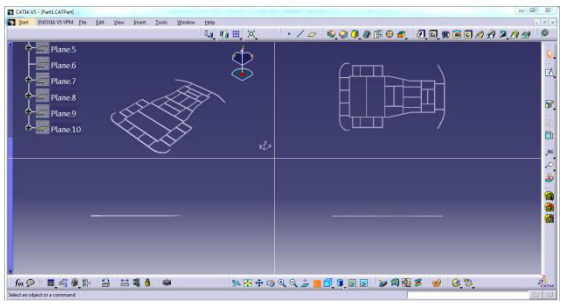

Figure 2 Multiple views of Gokart Frame

6 STATIC ANALYSIS

A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time varying loads. A static analysis can, however, include steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the

6.1 ANALYSIS PROCEDURE IN ANSYS: Designed component in catia workbench after imported into ansys workbench now select the Static analysis

1.ENGINEEERING MATERIALS (MATERIAL PROPERTIES).

2.CREATE OR IMPORT GEOMENTRY.

3.MODEL(APPLY MESHING).

4.SET UP(BOUNDARY CONDITIONS)

5.SOLUTION

6.RESULTS

6.2 BOUNDARY CONDITIONS :

Load of Driver, Driver Seat and Engine were taken into consideration while load of steering system,

fuel tank, etc. is low as compared to above components hence it can be neglected. Also, as chain drive transmission system is used load of transmission system can also be neglected. Finally we taking load Front Impact:3328.6N, Side impact:2633. Taking materials are (**AISI 1030, AISI 4340, ASTM A710**)

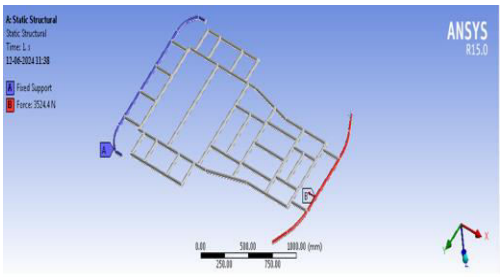

Figure 3 Boundary Conditions Front impact 3524.4N

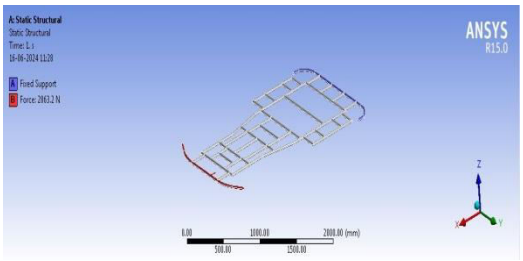

Figure 4 Boundary Conditions Front impact 2863.2N

7 RESULTS AND DISCUSSIONS

A fully parametric model designed in catia v5 of the gokart chassis software. Model obtained in igs is analyzed using ANSYS 15 (work bench) to obtain stresses, strain, deformation, Shear stress and in modal analysis, find out the deformations different frequencies, Front and side impact manual calculations are done Finally, we compare the results obtained from ANSYS **(SATIC, MODAL)** and compared different materials. ASTM A710, AISI 4340, AISI 1030) as shown below figures.

FRONT IMPACT OF AISI 4340 MATERIAL:

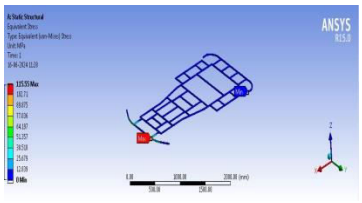

Figure 5 Von-misses stress of AISI 4340 Material

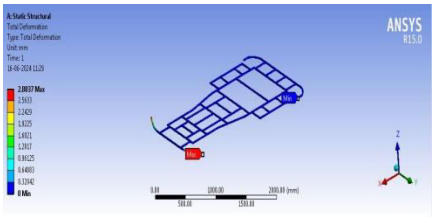

Figure 6 Total deformation of AISI 4340 Material

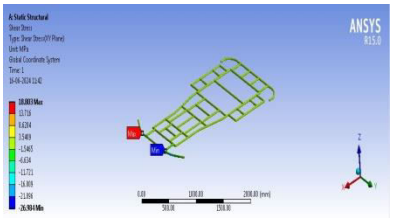

Figure 7 Shear stress of AISI 4340 Material

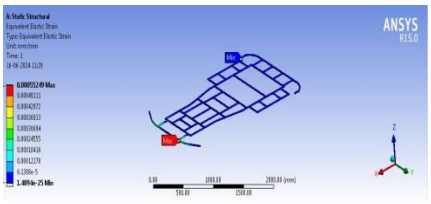

Figure 8 Strain of AISI 4340 Material

FRONT IMPACT OF ASTM A710 MATERIAL:

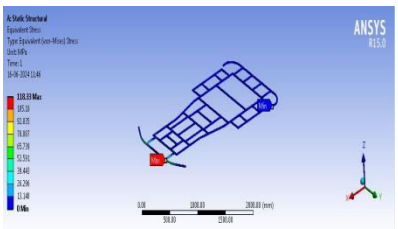

Figure 9 Von-misses stress of ASTM A710 Material

7.1 FRONT IMPACT GRAPHS:

Von-misses stress graph:

From below Graph, we can observe that in case of Von-misses stresses of go-kart chassis when apply front impact chassis 3524.4N and fixed at back part and using various materials (ASTM A710, AISI 4340, and AISI 1030) is finally observed to have least Von-misses stress of AISI 4340 material

115.55 Mpa of in comparison with remaining materials

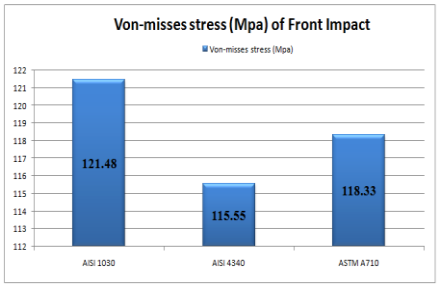

Figure 10 Von-misses stress graph

Shear stress graph:

From below Graph, we can observe that in case of Shear stress of go-kart chassis when apply front impact chassis 3524.4N and fixed at back part and using various materials (ASTM A710, AISI 4340, and AISI 1030) is finally observed to have least Shear stress of AISI 4340 material 18.803Mpa of in comparison with remaining materials

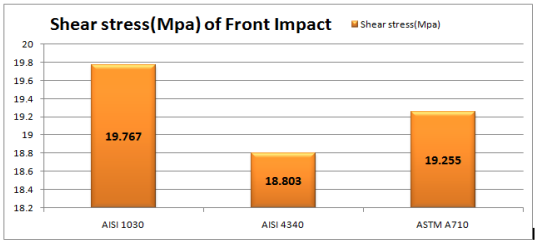

Figure 11 Shear stress graph

Total deformation graph:

From below Graph, we can observe that in case of Total deformation of go-kart chassis when apply front impact chassis 3524.4N and fixed at back part and using various materials (ASTM A710, AISI 4340, and AISI 1030) is finally observed to have least Total deformation of AISI 4340 material 18.803Mpa of in comparison with remaining materials

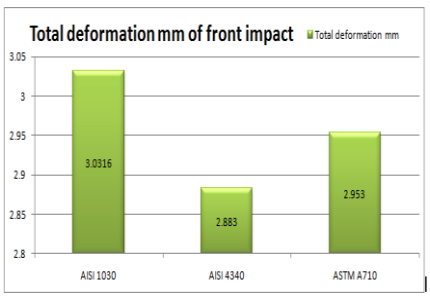

Figure 12 Total deformation graph

8 CONCLUSION

To achieve the set goals, we used the finite element for the evaluation, creation and modification of the best vehicle design. Our prior aim was to build a go kart with minimum cost without compromising the safety and performance of the vehicle. The final result is a desired Go Kart design meeting all the above factors.circular section go-kart design and analysis are done with **AISI 1030, AISI 4340, ASTM A710** materials finally Result concluded that the **AISI 4340**material is gives better performance compared to the Remaining material, **AISI 4340**is the suitable material to be used for the go-kart chassis because of High Strength to weight ratio., Rigidity, Corrosion resistance, , Fatigue Resistance. we are concluded based on stresses,strain and deformation values the suitable material for gokart. Static ,Modal analysis is performed using finite element method was successfully carried out on chassis catia model to determine in Ansys equivalent stresses, maximum deformations, Hence the chassis design is safe with **AISI 4340** material compared to remaining material than proceed the manufacturing process.

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